# Ground Water in the Coastal Dune Area Near Florence, Oregon

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1539-K

*Prepared in cooperation with the city of Florence, Oregon*

Hampton GROUND WATER IN THE COASTAL DUNE AREA NEAR FLORENCE, OREG.—Geological Survey Water-Supply Paper 1539-K

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*By* E. R. HAMPTON

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

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U.S. DEPARTMENT OF THE INTERIOR
March 3, 1849

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1963

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington 25, D.C.

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# GROUND WATER IN THE COASTAL DUNE AREA NEAR FLORENCE, OREGON

By E. R. HAMPTON


## ABSTRACT

The coastal areas of Oregon are characterized by bedrock of Tertiary age that is impermeable or, at best, yields only small quantities of water to wells and springs. Water found at depth in these rocks may be saline and unsuitable for human consumption. At some places, as near the city of Florence, the bedrock is overlain by extensive and thick deposits of dune sand. The dune sand is permeable and absorbs and stores a high percentage of the 65-inch annual precipitation. Accordingly, large quantities of water are available for withdrawal in the Florence dune-sand area. About 48 of the estimated 55 inches of average annual recharge, or about 830 million gallons per square mile per year, discharges from the dune sand, and most of that water could be recovered from wells. Total average natural discharge from the 18-square-mile area, including that by evapotranspiration, is about 50,000 acre-feet per year.

The water is soft and of generally good chemical quality; however, it is weakly acidic, and at places it contains objectionable amounts of iron. Ground water beneath a few swampy, low-lying areas is excessively high in iron and has objectionable taste, odor, and color.

Although the maximum thickness of the dune sand tested was only 81 feet, the sand probably is at least 100 feet thick throughout most of the area and may be as much as 200 feet thick locally.

The most practical method for withdrawing moderate to large quantities of water from the dune sand probably will entail the use of properly screened and developed wells. A 6-inch test well, designed and constructed during this study, utilizes only a short length of screen and was not completely developed; nevertheless, during a brief pumping test it yielded water at about 55 gallons per minute with 8 feet of drawdown.


## INTRODUCTION

### PURPOSE AND SCOPE OF THE INVESTIGATION

The coastal region is mostly underlain by poorly permeable rocks of Tertiary age, which, at best, store and yield very small quantities of ground water. The meager supplies of water yielded to wells by these rocks is usually of poor chemical quality. Even the streams in the region do not constitute adequate water supplies in most places. Most of them are extremely flashy—bankfull during major storms of the rainy season and nearly dry during the dry summer months.

Preliminary studies of the dune area north of Coos Bay (about 40 miles south of Florence) by the Geological Survey (Brown and Newcomb, 1962), and independent studies made later by the Pacific Power & Light Co., have shown that the dune sand there stores and will yield to wells large quantities of water of good quality. The water in that and similar bodies of dune sand represents a substantial source of additional perennial supplies in much of the coastal region. The dune areas represent an important recreational resource also.

The purpose of this investigation is to determine the occurrence, quality, and availability of ground water in a part of the Florence dune sheet, one of the largest dune-sand areas on the Oregon coast.

Fieldwork was begun by the author in June 1959. The geologic setting of the area was surveyed and hydrologic data were collected in the ensuing summer months of 1959. A network of 26 wells was constructed for testing and for periodic measurement of ground-water levels. The elevation of each well was established by third-order leveling. Staff gages were installed in three lakes and on two streams, and the lake levels and stream stages were recorded weekly or biweekly, as were the water levels in the observation wells. Water samples were collected and analyzed for chemical quality, sand samples were analyzed for particle size and other hydraulic properties, and pumping tests were made to determine the water-storage and water-yielding properties of the sand. A 6-inch test well was drilled to explore the nature of the sand at moderate depths and to determine the yield of a well employing a properly selected screen in the dune sand.

The investigation was made by the U.S. Geological Survey in cooperation with the city of Florence, Oreg. The study was under the immediate supervision of Bruce L. Foxworthy, district geologist in charge of ground-water studies in Oregon, and R. C. Newcomb, former district geologist. The author was assisted in the field by John M. Blackwell and Tad L. Fyock.

## LOCATION AND EXTENT OF THE AREA

The Florence dune sheet extends southward along the Oregon coast from Heceta Head (lat 44°07′ N.) to the mouth of the Umpqua River (lat 43°45′ N.) near Reedsport, Oreg., a distance of about 25 miles. The dune sheet ranges in width from about 2½ miles near Florence to less than half a mile near Reedsport. That part of the dune sheet lying north of the Siuslaw River is referred to as "the Siuslaw River north dune area" by W. S. Cooper (1958, p. 88) but is called the northern Florence dune area in this report.

The part of the dune sheet covered most intensively by this investigation is a 5-square-mile area that lies generally north and west of the Siuslaw River, east of U.S. Highway 101, and south of Sutton Lake (fig. 1 and pl. 1). This area is herein called the Munsel Creek sector of the northern Florence dune area.

## GEOGRAPHIC SETTING

### CLIMATE

The Florence area has a temperate marine climate. Precipitation data available for it or adjacent areas include a 25-year precipitation record for Canary, a station about 7 miles south of and about 100 feet higher than Florence, and a 19-year precipitation record for Florence. The precipitation data for Florence were partly interpolated by the author from Weather Bureau records collected at Canary, Reedsport (20 miles south of Florence), and Florence 3NW (at the Siuslaw Station, U.S. Coast Guard, about 2 miles northwest of the city), and partly from records from the city of Florence's rain gage, which has been operating since 1957.

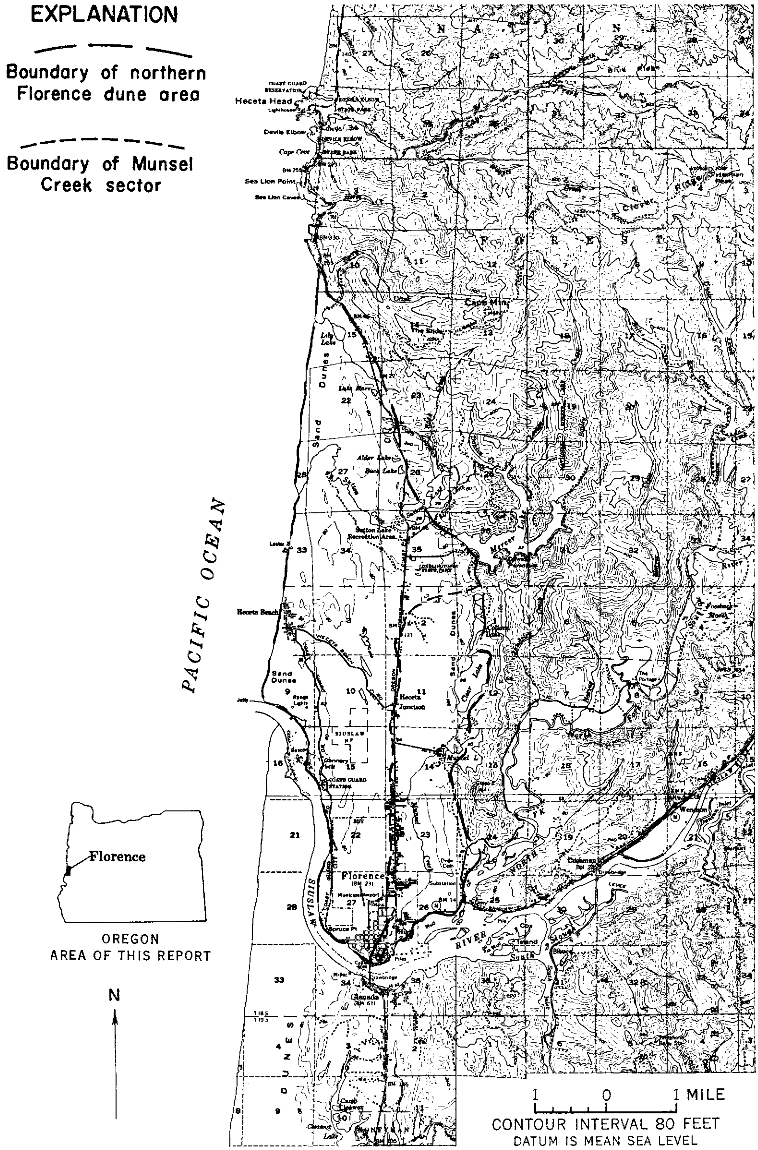
The average annual precipitation at Florence is about 65 inches; almost all occurs as rain, and about three-fourths falls during the autumn and winter months (fig. 2).

The average annual precipitation at Canary for the period of record was 79.85 inches. Figure 3 shows precipitation at Canary for the period of record and the cumulative departure from the average precipitation for the 25-year base period October 1, 1932, to September 30, 1957 (water years 1933–57).

Temperatures at Florence are not recorded but can be approximated from temperature data from the Weather Bureau station at Reedsport. Those data show that the average maximum temperatures at the Reedsport station were about 61°F for July and August, the warmest months, and that the average minimum temperature was 44.5°F for January, the coolest month. The mean annual temperature at Reedsport is about 52°F.

### TOPOGRAPHY AND DRAINAGE

The northern Florence dune area is characterized by a low, undulating surface that slopes gently upward from the sea to the base of the bedrock ridges that form the eastern boundary of the dune sheet. The dune sheet is divided by an eastward-trending topographic high (sec. A–A′, pl. 1), the axis of which is about three-fourths of a mile south of Sutton Lake. The highest points on the dune sheet are near or on that topographic high, attaining altitudes above 160 feet.




Base from U. S. Geological Survey topographic quadrangles Heceta Head and Siltcoos Lake, 15', 1956

FIGURE 1.—Map of the northern Florence dune area and adjacent areas.

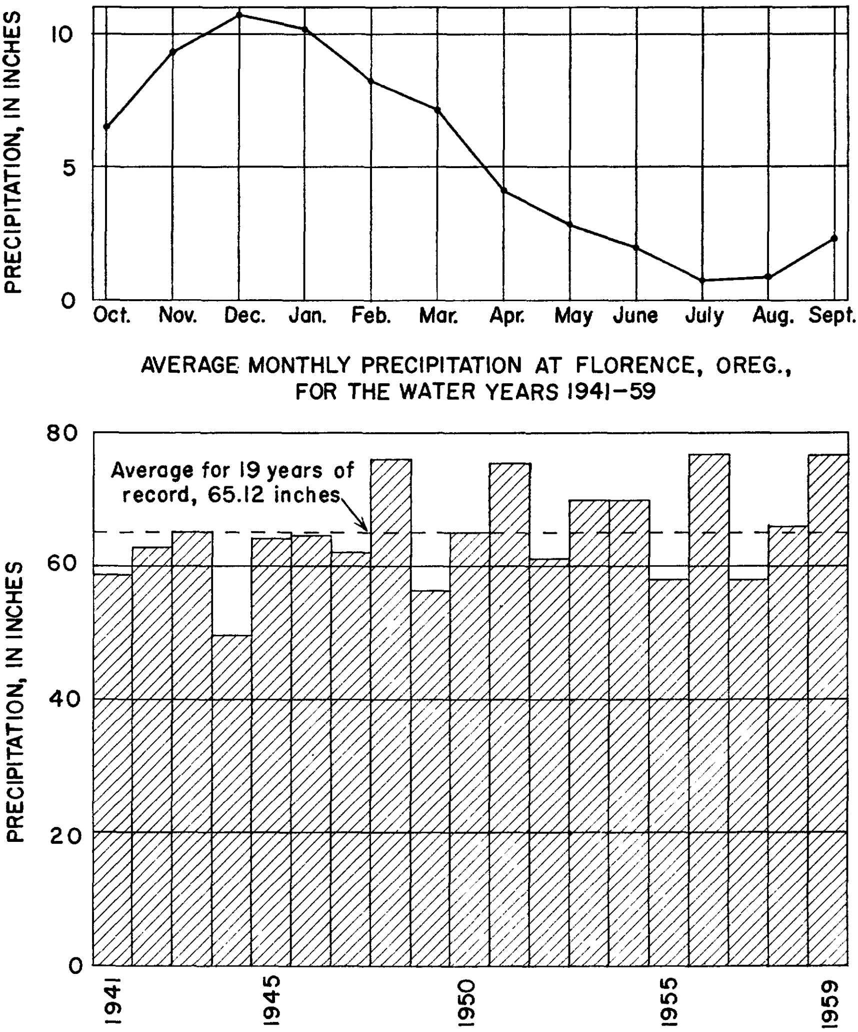



FIGURE 2.—Annual and average monthly precipitation at Florence, Oreg., water years 1941–59. Monthly totals for some months in all water years except 1947, 1948, and 1955 are interpolated. Data for 1959 are from the city of Florence precipitation records.

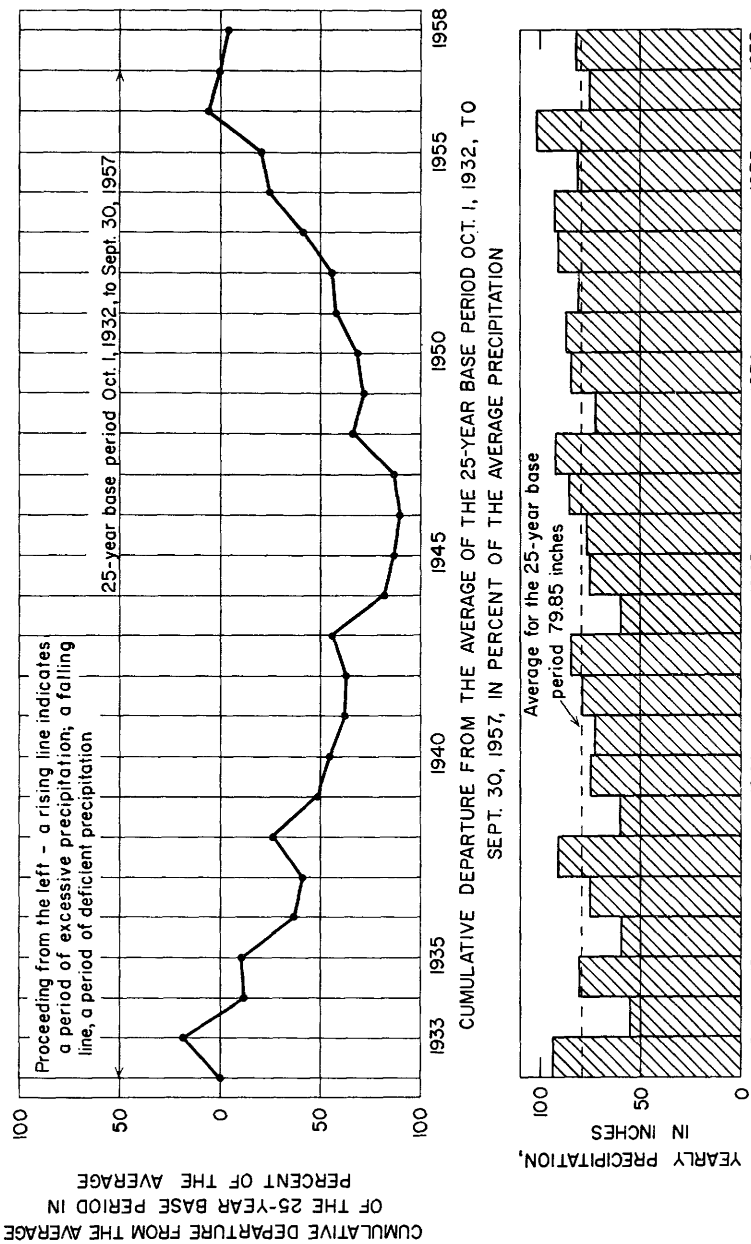



FIGURE 3.—Annual precipitation and cumulative departure from the average precipitation, at Canary, Oreg., water years 1933–58.

The northern Florence dune area is drained by a few small streams. These are Sutton and Munsel Creeks, and one small unnamed creek. There is surface flow to the streams from the bedrock hills to the east of the area, and from lakes that are connected by the streams or that drain to the streams.

The area south of the topographic high, including the Munsel Creek sector, is drained through a series of interconnected lakes and Munsel Creek. The lakes lie in a north–south line along the east edge of the dune sheet, and are connected by short streams. Their names, from north to south, are Collard, Clear, Acrely, and Munsel Lakes. The altitudes of their surfaces range from about 110 feet at Collard Lake to about 90 feet at Munsel Lake. Munsel Creek is the outlet of Munsel Lake.

### CULTURE AND INDUSTRY

The major industries in the Florence area are logging and lumbering; packing of ferns, shrubs, and evergreen cones for shipment; processing of fish; construction; and providing tourist facilities.

Although no population figures are available for the northern Florence dune area as a whole, the Oregon State Board of Census estimated that the population of the city of Florence as of July 1, 1959, was 1,775, which indicates a population increase of about 73 percent during the period 1950–59. In addition to the people living in Florence, perhaps another 500 live outside the city limits in the northern Florence dune area.

The dune area is served by U.S. Highway 101, many secondary roads, and trails passable only with "beach buggies" and four-wheel-drive vehicles.

### WELL-NUMBERING SYSTEM

Wells discussed in this report are designated by symbols that indicate their location according to the rectangular system of land division. In the symbol 18/12W-14Q1, for example, the part preceding the hyphen indicates the township and range (T. 18 S., R 12 W.) south and west of the Willamette base line and meridian. Because most of the State lies south of the Willamette base line, the letter indicating the direction south is omitted, but the letter "W" is included for wells lying west of the meridian. The first number after the hyphen indicates the section (sec. 14), and the letter "Q" indicates a 40-acre subdivision of the section as shown in the diagram below. The final digit is the serial number of the well within that 40-acre tract. Thus, well 18/12W-14Q1 is the SW¼SE¼ sec. 14, T. 18 S., R. 12 W., and is the first well in the tract to be listed (fig. 4).

Records of representative wells in the area are listed in table 5, and drillers' logs of some of those wells are listed in table 6.

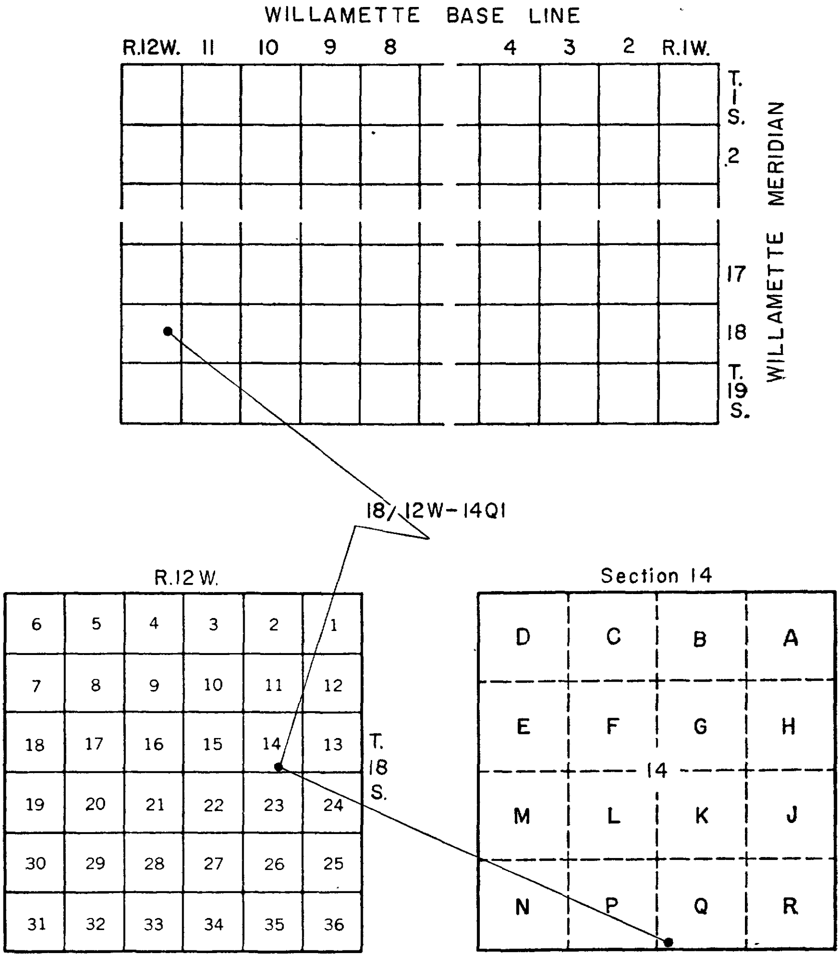



FIGURE 4.—Diagram of the well-numbering system used in the area.

## GEOLOGIC SETTING

A brief description of the geologic setting of the area, especially with reference to the water-yielding properties of the rock units, is necessary to evaluation of the overall hydrologic conditions.

The major geologic units in the Florence area were mapped by Baldwin (1956). On his map, Baldwin differentiated the Tyee formation, volcanic rocks, and intrusive rocks—all of Tertiary age—and Quaternary alluvium, in which he included the dune sand. The distribution of the rock units, modified after the map of Baldwin, is shown in plate 1.

The rocks of Tertiary age are poorly permeable and yield only small quantities of water to wells. The Quaternary alluvium, which underlies the terraces and the floors of stream valleys, is composed of clay, silt, sand, and, at places, gravel. The coarser materials of the alluvium may yield small to moderate quantities of water to wells, but no wells in the Florence area are known to penetrate these materials.

The dune sand, of Quaternary age, overlies the planed-off surface of the Tyee formation. The sand is believed to be at least 100 feet thick beneath most of the area; where high dune ridges are present, it probably attains thicknesses exceeding 200 feet. The sand consists principally of quartz but contains subordinate amounts of olivine, magnetite, epidote, zircon, feldspar, and undetermined rock fragments. The grains range in size from medium to very fine (figs. 5–8; table 1) and are subangular to rounded. As the figures show, the particles of the four samples included clay (particles less than 0.004 mm in diameter), silt (0.004–0.0625 mm), very fine sand (0.0625–5.125 mm), fine sand (0.125–0.25 mm), and medium sand (0.25–

TABLE 1.—*Weight percentage of particles in samples from wells in the Florence area*
[Particle diameters in millimeters]

| Well or test hole | Graph on figure— | Clay (0.004) | Silt (0.004–0.0625) | Sand | | |
|---|---|---|---|---|---|---|
| | | | | Very fine (0.0625–0.125) | Fine (0.125–0.25) | Medium (0.25–0.5) |
| 18/12W–26B1 | 5 | 0.6 | 2.2 | 1.4 | 71.8 | 24.0 |
| 23Q1 | 6 | .2 | .4 | 1.0 | 82.4 | 16.0 |
| 14R1 | 7 | .4 | 1.0 | .2 | 51.6 | 46.8 |
| 26B3 | 8 | .4 | 1.0 | .2 | 41.8 | 56.6 |

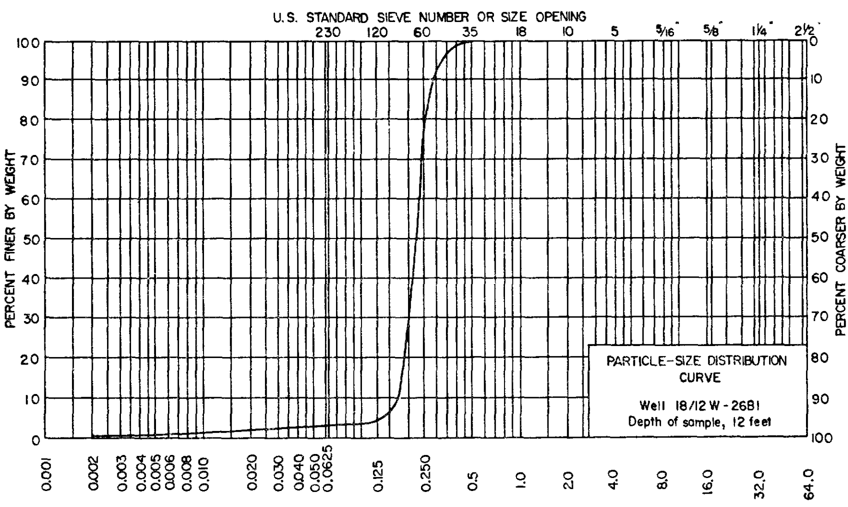



FIGURE 5.—Results of particle-size analysis of dune sand from well 18/12W–26B1.

0.5 mm). The range in distribution of the particles in the various size classifications, in the percentage by weight of the total sample, was as follows: clay, 0.2–0.6; silt, 0.4–2.2; very fine sand, 0.2–1.4; fine sand, 41.8–82.4; medium sand, 16–56.6.

As shown by the size-distribution curves on figures 5 to 8, the dune sand is very uniform. Observations in the field indicate that the sand is mostly loose and homogeneous but that it contains minor layers of

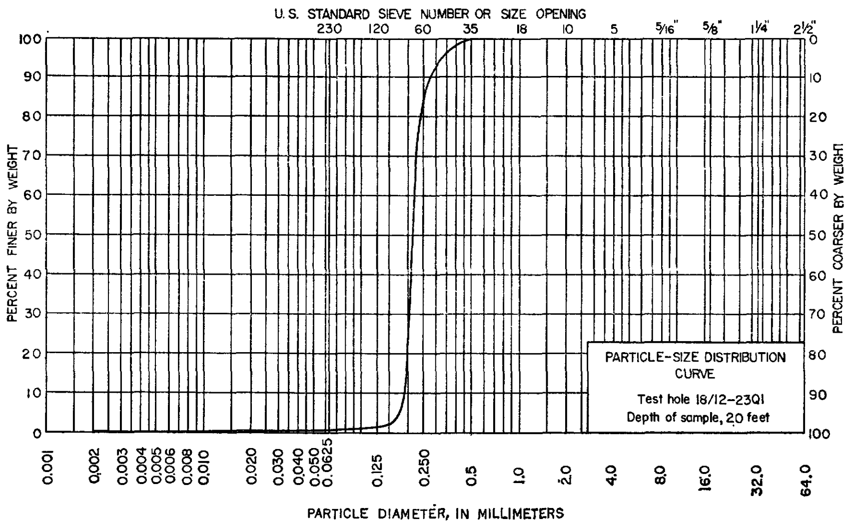



**FIGURE 6.—Results of particle-size analysis of dune sand from test hole 18/12W–23Q1.**

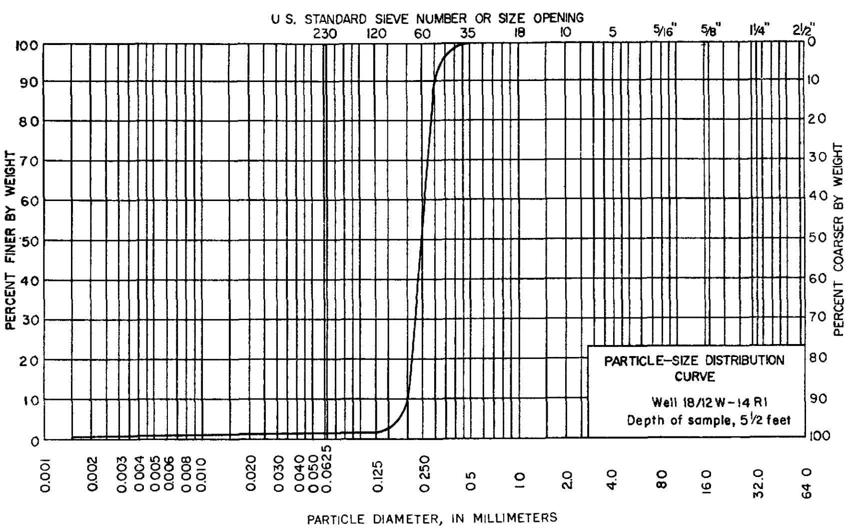



**FIGURE 7.—Results of particle-size analysis of dune sand from well 18/12W–14R1.**

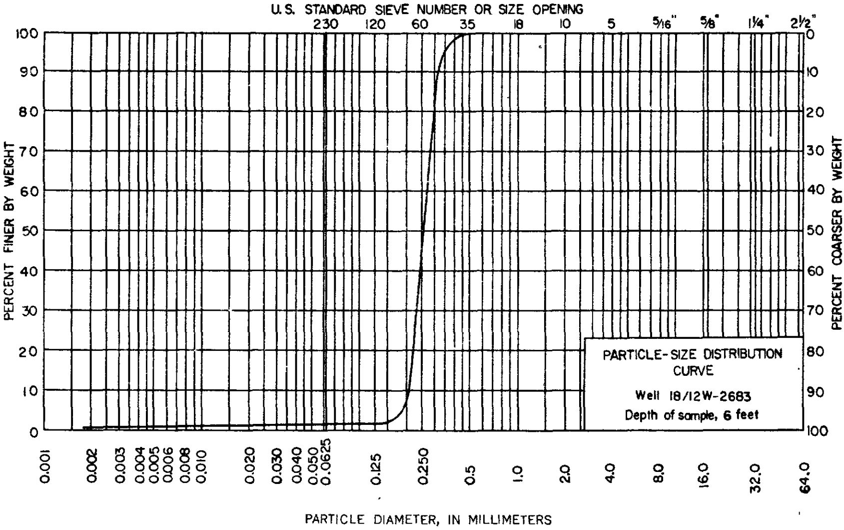



FIGURE 8.—Results of particle-size analysis of dune sand from well 18/12W–26B3.

peat and at places is weakly cemented by limonite. Peat layers observed along the estuary of the Siuslaw River are about 1 foot thick. The cemented layers range in thickness from a few inches to about 1 foot. The peat and cemented layers probably are the remnants of former swampy or marshy areas.

The dune sand is by far the most productive aquifer in the Florence area. The hydrologic properties of the sand are described in a following section on the ground water.

## ACKNOWLEDGMENTS

This study was facilitated by many of the local residents. The employees of the water-treatment plant of the city of Florence gave valuable assistance by measuring the water levels in observation wells and recording the water levels in lakes for many months. Private individuals provided interesting information on the fluctuation of the water table, and physical changes effected by the moving sand dunes during the last 50 years. Well records and general information on wells were provided by Mr. C. E. Panschow, a well driller in the Florence area. The assistance of all is gratefully acknowledged.

## GROUND WATER

### GENERAL FEATURES OF OCCURRENCE

Below a certain depth, the earth's materials are saturated with water under hydrostatic pressure. The top of the zone of saturation is called the water table, and the water below is called ground water. In most areas, the precipitation that falls on the land surface and does not run off into streams or evaporate, or is not transpired by vegetation, percolates downward through the soil and other rock materials until it reaches the water table.

In areas underlain by poorly permeable materials, most of the precipitation quickly runs off in surface streams; whereas, in areas underlain by moderately to highly permeable materials, proportionately more precipitation infiltrates beneath the surface. Thus, some of the precipitation that falls on an area underlain by permeable materials usually percolates downward to the ground-water body.

Ground water moves under the force of gravity from areas of recharge, where water is added to the ground-water body, to areas of discharge, where it leaves the ground-water body. Ground water may discharge principally as seeps or springs, either at the land surface or to surface-water bodies; however, in its underground course the ground water may also be subject to losses by evaporation, transpiration by vegetation, and withdrawal from wells.

## GROUND WATER IN THE DUNE SAND

### SHAPE AND EXTENT OF THE GROUND-WATER BODY

The body of fresh ground water in the Munsel Creek sector is about 4½ miles long and 1¼ miles wide and ranges in thickness from an estimated 200 feet at its north end to about 100 feet at its south end. The existence of shallow domestic wells and ground-water ponds in other parts of the dune sheet indicate that the ground-water body in the Munsel Creek sector is but part of a larger, generally continuous but locally restricted body that underlies the entire Florence dune sheet. The upper surface of the ground-water body (water table) has the same general configuration as the land surface, though more subdued. As shown by the water-table map of the area, figure 9, the water table in the Munsel Creek sector had a southward slope of about 30 to 40 feet per mile on August 21, 1959.

The ground-water body in the Munsel Creek sector is at least partly separated from ground water in other parts of the northern Florence dune area by ground-water divides and by hydraulic boundaries. The known hydraulic boundaries in the Munsel Creek sector are (a) the marine sedimentary rocks that underlie the sand and abut the dune sheet on the east, (b) the Siuslaw River on the south and west, and (c) the lakes and streams within the dune sheet. The thin layers of peat and semiconsolidated silt in the dune sands may retard the vertical movement of the ground water and thus may act as minor hydraulic boundaries within the sand.

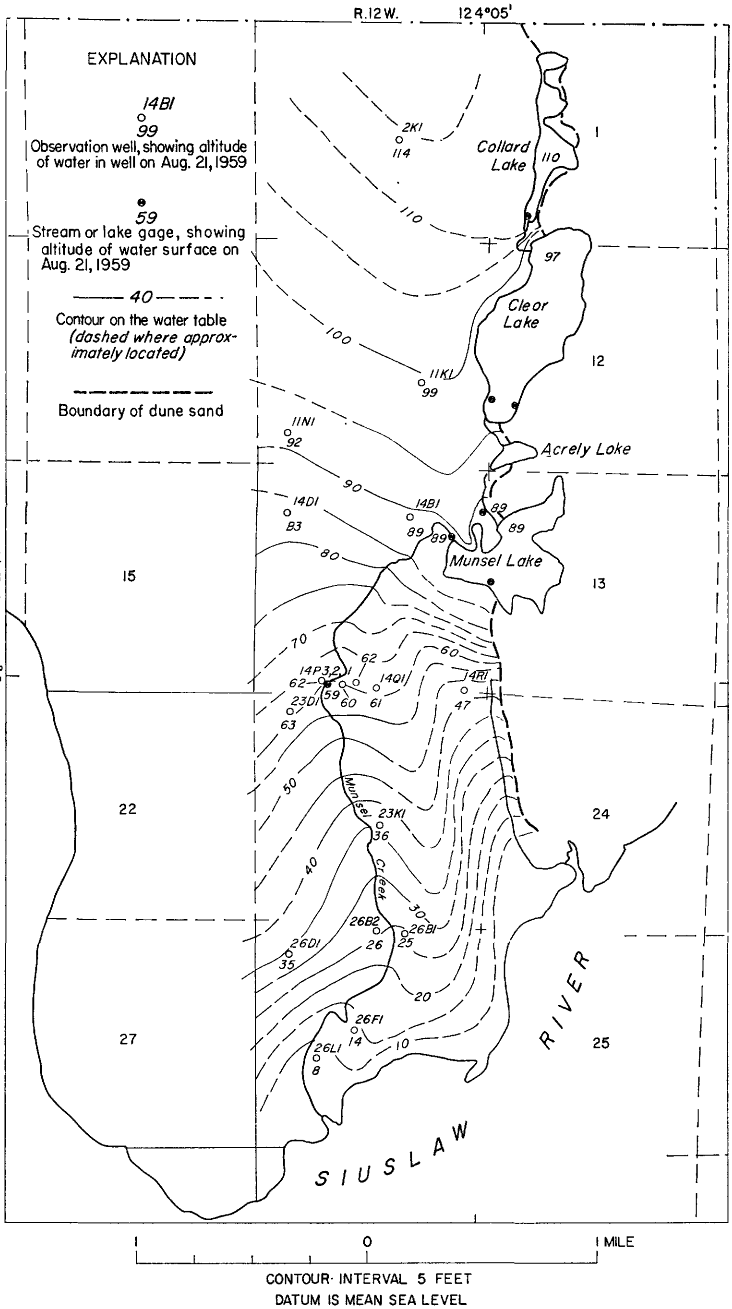



**Figure 9.—Water-table map of the Munsel Creek sector of the northern Florence dune area, Oregon, August 1959.**

### SOURCE AND RECHARGE OF THE GROUND WATER

The source of the ground water in the dune sand is the precipitation on the area. Dune sand in general is moderately permeable and allows infiltration of a high percentage of the precipitation that falls on it. In the Florence area, the dune sand intercepts such a high percentage of the precipitation that only three small perennial streams flow out of the dune area. Thus, most of the precipitation that falls on the sand goes to recharge the ground-water bodies. Of the 65-inch average annual precipitation in the Florence area, it is estimated that at least 55 inches, or about 85 percent, goes to recharge the ground-water body. Based on that estimate, the volume of water added to the ground-water body in each square mile averages about 3,000 acre-feet per year, or 2.7 mgd (million gallons per day).

### MOVEMENT AND DISCHARGE OF THE GROUND WATER

Ground water in the dune sand moves downgradient toward the edges of the dune sheet and eventually discharges from the aquifer. The movement of ground water in the Munsel Creek sector is generally southward to the Siuslaw River, although locally it is toward Munsel Creek. The hydraulic gradient in the Munsel Creek sector is shown by the water-table contours in figure 9.

In the northern part of the northern Florence dune area, beyond the Munsel Creek sector, the ground water moves westward and ultimately discharges into the Pacific Ocean. Locally, the channel of Sutton Creek diverts and intercepts part of the westward-moving ground water. In the southern part of the northern Florence area, the ground water moves to the south and west—away from the ground-water divide, whose axis is west of the contours shown on figure 9 and apparently follows U.S. Highway 101 from near Heceta Junction to near the city of Florence.

The ground water of the Florence dune area is discharged (a) as springs, seeps, and underflow to the Pacific Ocean, to the Siuslaw River, and to the three small streams that drain the area; (b) by evapotranspiration; and (c) by withdrawal from wells.

The discharge as springs, seeps, and underflow doubtless constitutes the major natural discharge. R. C. Newcomb of the Geological Survey (oral communication, 1959) estimates that about 500 gpm (gallons per minute) per mile drains from innumerable springs visible along the seashore from the North Jetty to Heceta Head. Even in the driest part of the year, there are quicksand areas along the beach near the mouth of Sutton Creek, indicative of rising, or effluent, ground water. The quicksand areas indicate that much more ground water discharges to the ocean as underflow without reaching the surface at the beach. Springs and seeps also occur all along the north and east banks of the Siuslaw River, and along the low-lying area adjacent to the North Fork of the Siuslaw River.

The amount of ground water discharged in the Florence dune area by evapotranspiration was not determined. In the Coos Bay dune area, which has a climate and a vegetative cover similar to that of the Florence dune area, Brown and Newcomb (1962, p. 22) estimated an average evapotranspiration discharge of about 7 inches per year. That estimate is considered reasonable also for the annual evapotranspiration in the northern Florence dune area as a whole. In parts of the area where the water table is shallow and the vegetation is dense, the evapotranspiration doubtless is much greater; conversely, in the barren dune areas, and at places where the water table is relatively deep, the evapotranspiration probably is considerably less than 7 inches per year. As will be shown, the total estimated natural discharge from the ground-water body in the northern Florence dune area is about 50,000 acre-feet per year.

The amount of ground water withdrawn from the dune sand in the Florence area by means of wells is not known, but doubtless it is insignificant in comparison to the amount that discharges naturally.

## FLUCTUATIONS OF THE WATER TABLE AND RELATION TO RECHARGE AND DISCHARGE

The water table in the northern Florence dune area is lowest in late autumn, after the season of meager rainfall, and highest in late winter or early spring, during the rainy season. The fluctuations of water levels measured in eight observation wells during the period June 1959 to June 1960, a period of nearly normal precipitation, are shown in figures 10 to 12. Although no long-term records of ground-water levels in this area are available, it can be expected that water levels lower than those recorded will occur during years of deficient precipitation and that levels somewhat higher than those recorded will occur during years of excessive precipitation.

In order to determine the diurnal fluctuation of the water table in the Munsel Creek sector, wells 18/12W–14P3 and 26B1 were measured once each hour during the 24-hour period ending at 8:00 a.m. August 14, 1959. Well 14P3 is in an area of dense vegetation and had a water level 4.4 feet below the land surface at the beginning of the measurements. Well 26B1 is in a barren area of shifting dunes, and had an initial water level 5.8 feet below the land surface.

The wells were measured by the wetted-tape method, and each well was measured with the same tape throughout the period. The tapes were carefully chalked between measurements with blue carpenters

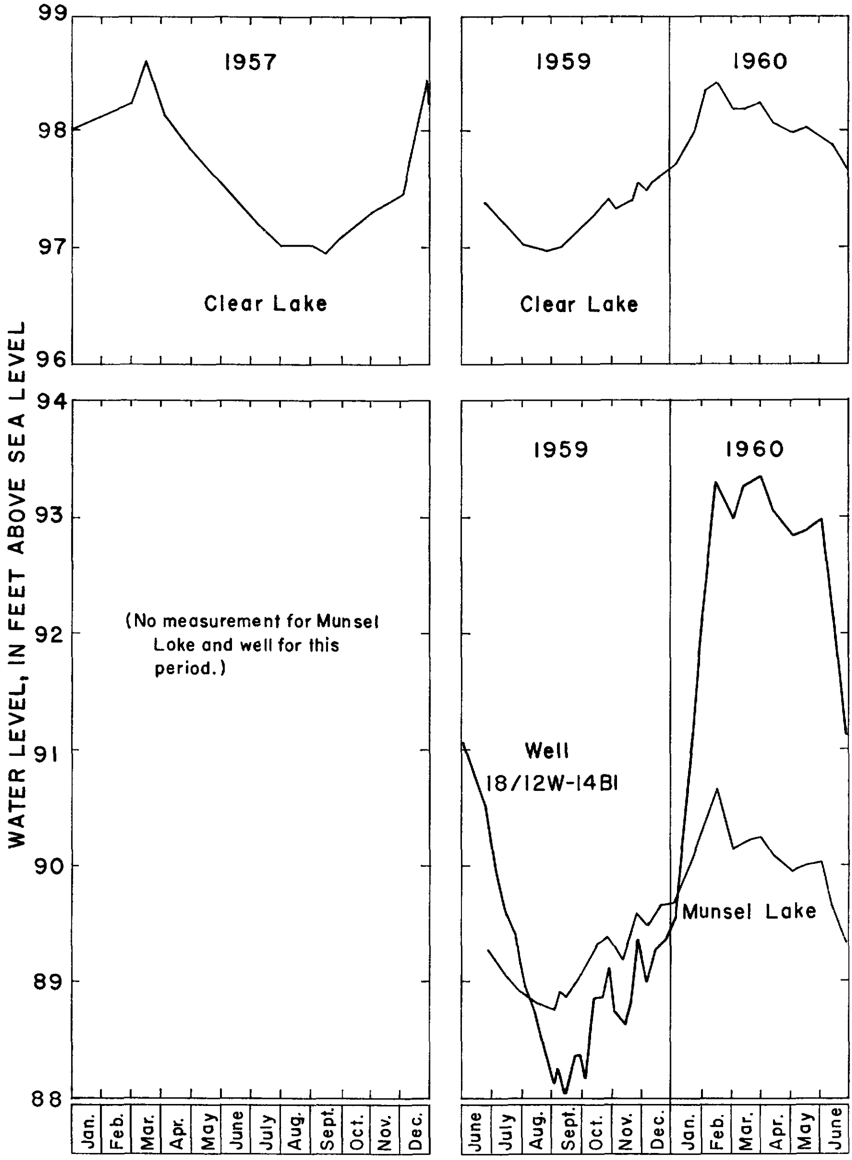



FIGURE 10.—Hydrographs of well 18/12W-14B1 and Clear and Munsel Lakes, comparing water-level fluctuations in the well with those of the lakes.

chalk on the face and gray-white diatomite on the back. The hourly levels recorded represent the average of 3 or 4 measurements read to the nearest 0.0025 foot. Hydrographs showing the water-level fluctuations at the wells are presented in figure 13.

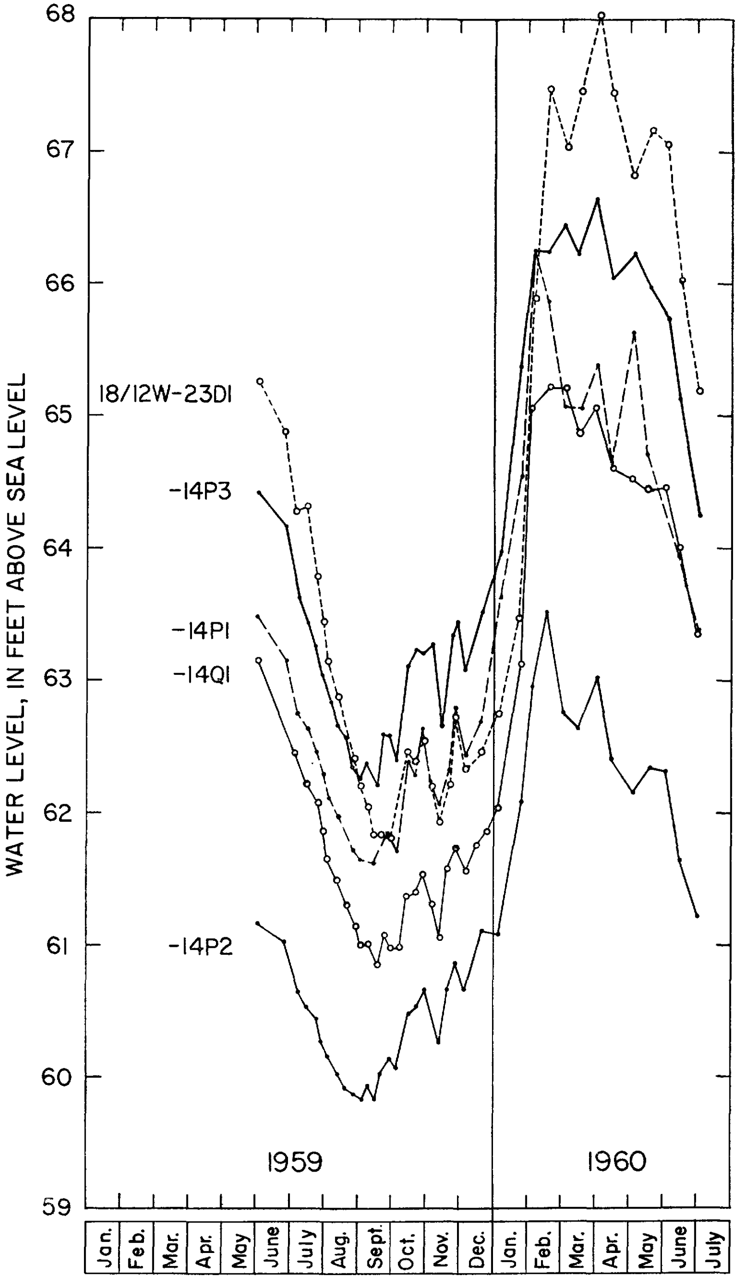



FIGURE 11.—Hydrographs of wells 18/12W–14P1, P2, P3, Q1, and 23D1 showing water-level fluctuations for the period June 1959–June 1960. Of this group, well 14P2 has the smallest fluctuation and is closest to Munsel Creek (a ground-water drain). Well 23D1 has the greatest fluctuation and is farthest from Munsel Creek.

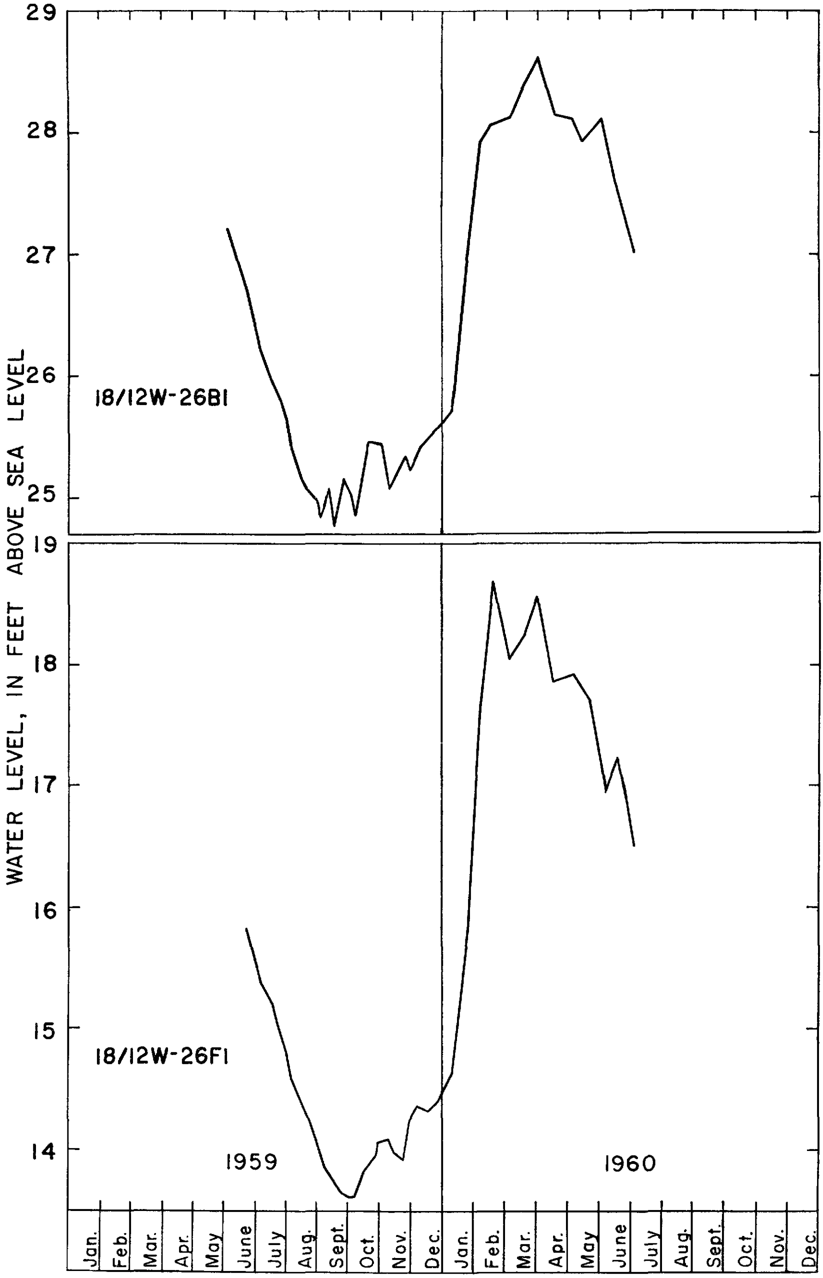



FIGURE 12.—Hydrographs of wells 18/12W-26B1 and F1 showing water-level fluctuations for the period June 1959–June 1960.

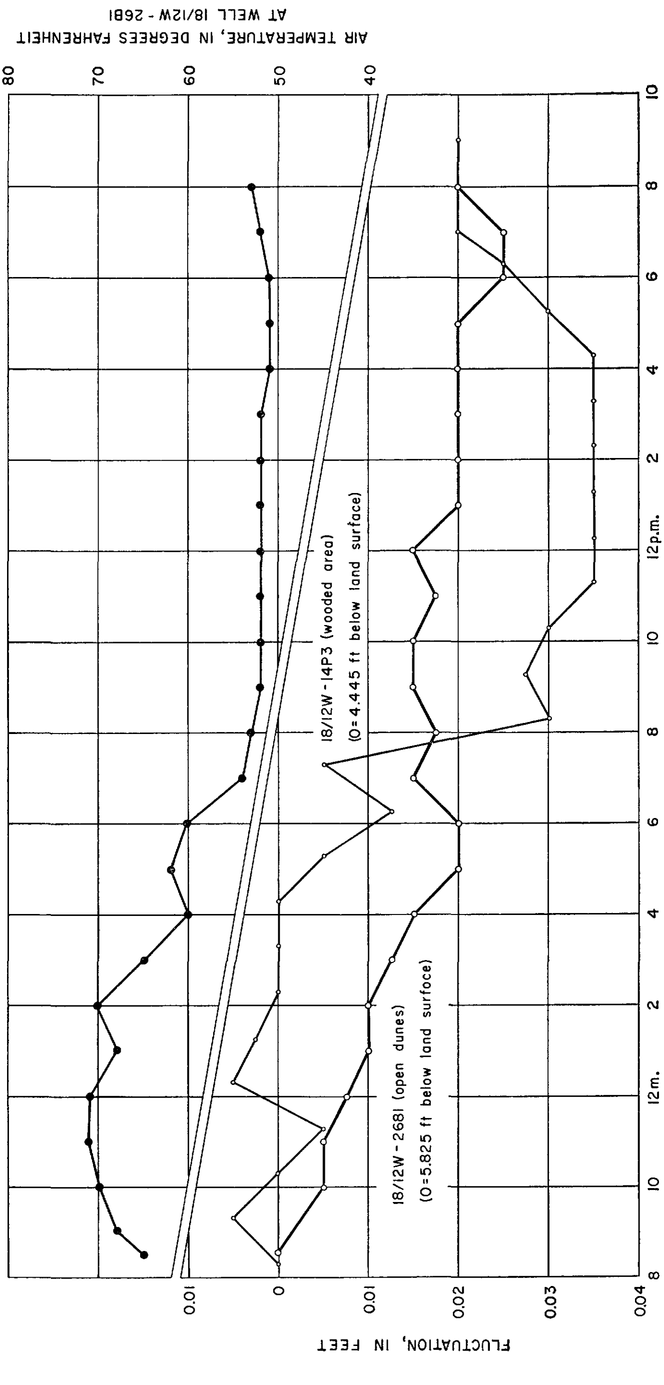



FIGURE 13.—Diurnal fluctuations of water levels in wells 18/12W–14P3 and 26B1, and air temperatures during the 24-hour period ended 8 a.m., Aug. 14, 1959.

The diurnal fluctuations shown in the hydrographs are very slight; the maximum was 0.04 foot in well 18/12W–14P3. Although the hourly fluctuations in the two wells did not coincide exactly, there was a general declining trend during the daytime, a general leveling off during the night, and a suggestion of a rising trend near the end of the period of measurement. A rise of less than 0.01 foot was recorded at both wells at about sundown (between about 6 and 7 p.m.) That slight rise coincides with an air-temperature drop of 7°F at the wells.

As previously described, the fluctuations of the water table in the Munsel Creek sector are closely related to variations in precipitation. A comparison of the change in water levels in the observation wells and the precipitation at Florence, shown in table 2, indicates that a minimum of about 4 inches of precipitation per month is required to provide recharge sufficient to maintain the water table within the median range of fluctuations noted during this investigation.

TABLE 2.—*Change in water levels of observation wells in relation to precipitation at Florence, Oregon*

| | 7-10-59 to 7-31-59 | 8-1-59 to 9-3-59 | 9-4-59 to 10-1-59 | 10-2-59 to 10-31-59 | 11-1-59 to 11-28-59 | 11-29-59 to 12-26-59 | 12-27-59 to 1-23-60 | 1-24-60 to 2-19-60 | 2-20-60 to 3-18-60 |
|---|---|---|---|---|---|---|---|---|---|
| Change in water level [1] feet | −0.55 | −0.82 | +0.04 | +0.52 | +0.13 | +0.09 | +1.46 | +1.91 | −0.24 |
| Precipitation [2] inches | .06 | .58 | 4.68 | 5.35 | 4.01 | 4.71 | 7.87 | 13.72 | 6.55 |

[1] Composite water-level change, derived from records from 16 wells.
[2] From daily precipitation records at Florence.

More precipitation (recharge) is required to maintain the water table at a high level than at a low level. This is because, as the water table rises, the hydraulic gradient steepens, and the ground water moves more rapidly to areas of discharge. The relation of the precipitation and water-level change during the period February 20, to March 18, 1960, shown in the foregoing table, demonstrates this phenomenon.

From the above discussion it is apparent that the relation of precipitation and water-table fluctuations in the Florence area is similar to that reported for the Coos Bay dune area by Brown and Newcomb, who state (1962, p. 20):

> Thus, it appears that approximately 4 to 5 inches of precipitation per month is necessary to meet the evapotranspiration losses and the ground-water outflow from the area, and to maintain the water table within the ranges of altitude observed during the investigation.

The recharge to the northern Florence dune area as a whole is estimated as 55 inches per year. If the water table is to remain within the range of altitudes observed during this investigation, an equal amount of ground water must be discharged. Therefore, in the 18-square-mile northern Florence dune area the ground-water discharge, including that by evapotranspiration, would be expected to average about 50,000 acre-feet per year, or about 45 million gallons per day.

## RELATION OF THE GROUND WATER TO LAKES AND STREAMS

The levels of lakes and the flows of streams in the Munsel Creek sector are maintained principally by ground water discharging from the dune sand.

Collard, Clear, Acrely, and Munsel Lakes, the major lakes in the Munsel Creek sector, receive surface runoff from a small area of Tertiary rocks to the east of the dune sand, but most of the inflow to the lakes is effluent ground water from the adjacent sands. The parallelism of the fluctuations of lake and ground-water levels, shown in figure 10, indicates that the position of the water table adjacent to Clear and Munsel Lakes controls the lake levels to a considerable extent. However, because the lakes have surface outlets, their levels are more nearly constant than the ground-water levels in the adjacent dune sand. The relative positions of the lake levels and the water table in August 1959 are shown in the water-table map, figure 9.

Most of the time, the streams in the area behave as ground-water drains. The lack of well-defined channels tributary to the lakes and major streams is evidence that very little of the precipitation leaves the dune area by direct runoff. It is only during times when the rainfall exceeds the intake capacity of the sand, or at places where the sand is saturated and thus can accept no additional recharge, that water runs off at the surface of the sand. Normally, the water table adjacent to the streams stands higher than the stream levels, and water discharges from the ground-water body to the streams. If recharge is sufficient to maintain the water table above the stream channel throughout the year, the streams will flow continuously. Otherwise, the water table declines below the level of the streambed and the streams cease to flow.

Munsel Creek normally receives ground-water discharge throughout the year and flows perennially. Because it acts as a ground-water drain, its flow increases downstream. The flow of Munsel Creek was mesaured on May 20, 1959, at the outlet of Munsel Lake and also at a point about 1 mile downstream. Within that reach, the flow of the creek increased about 3 cfs (cubic feet per second), from about 9 to about 12 cfs. During the summer months, effluent ground water can be observed seeping into Munsel Creek along most of the lower course of the creek.

## PHYSICAL AND HYDRAULIC PROPERTIES OF THE DUNE SAND

Samples of dune sand were collected at four localities and analyzed for specific retention, specific yield, coefficient of permeability, distribution of moisture above the water table (includes distribution of water in the capillary fringe), and particle size. The results of these analyses are summarized in tables 1 and 3 and are presented in figures 5–8 and 14–17. The following definitions of hydrologic terms should help the reader evaluate the results of the laboratory analyses. The definitions are essentially the same as those used by the Hydrologic Laboratory, of the U.S. Geological Survey, Denver, Colo., where the analyses were made.

The *porosity* is the ratio of the volume of the void spaces to the total volume of the rock or aggregate sample. It represents the upper limit of saturation when all voids are filled with water—that is, the total waterholding capacity of soil or rock material.

*Permeability* is the capacity of soil or rock materials to transmit water under pressure. It may be determined in the laboratory by observing the rate of percolation of water through a sample of known length and cross-sectional area. The *coefficient of permeability,* as used by the Gelogical Survey, is defined as the rate of flow of water, in gallons per day, through a cross section of 1 square foot under a hydraulic gradient of 1 foot per foot at a water temperature of 60°F.

TABLE 3.—*Summary of laboratory-analysis data from samples from wells in the Florence area*

| Sample from well— | Depth (feet) | Specific retention (percent) | Porosity (percent) | Specific yield (percent) | Coefficient of permeability (gpd per sq ft) |
|---|---|---|---|---|---|
| 18/12W–26B1 | 12 | 5.8 | 39.2 | 33.4 | 270 |
| 26B3 | 6 | 4.3 | 38.8 | 34.5 | 600 |
| 14R1 | 5.5 | 4.5 | 39.5 | 35.0 | 600 |
| 23Q1 | 20 | 4.2 | 36.5 | 32.3 | 410 |

The *coefficient of transmissibility* is rate of flow of water, in gallons per day, at the prevailing water temperature, through each vertical strip of aquifer 1 foot wide and extending the full saturated thickness of the aquifer, under a hydraulic gradient of 1 foot per foot.

The *specific retention* of a rock is the percentage of its total volume occupied by water which will not drain from the rock by gravity and which therefore will not be yielded to wells.

The *specific yield* of a rock is the percentage of its total volume occupied by water that will drain from the rock by gravity. The specific yield of a rock is equal to its porosity minus its specific retention.

The *capillary rise* is the height to which water will rise by capillary action in a column of soil, sand, or other material above a free water surface. In general, the height of rise and the time required to approach the maximum rise increase with a decrease in particle size.

Figures 14 through 17 show laboratory determinations of the distribution of moisture above the water table in the sand samples. The curves represent the vertical distribution of moisture, in percentage by volume, that is present in a column of the sand after water has been allowed to rise into the dried sand from a reservoir representing the ground-water body. It is significant that as much as 2½ percent of moisture is present in the test samples at a height of 34 feet above the water table. This moisture, in conjunction with the relatively large amount of moisture retained from water infiltrating the sand (see specific retention, p. 22) probably accounts for the dampness found at shallow depths in the dune sand throughout the summer of 1959, at heights exceeding 80 feet above the water table. The water in the sand above the water table probably supplies most of the water to the roots of vegetation in the area.

As has been observed in the field, and as is supported by the particle-distribution curves, the dune sand approaches the ideal aquifer whose properties are assumed in the equations developed to derive coefficients of storage, permeability, and transmissibility from pumping tests and other field-testing data. This ideal aquifer is homogeneous, isotropic, and of infinite lateral extent. Because of the even texture and virtual lack of bedding in the dune sand, a disturbed sample of the sand probably has nearly the same hydrologic properties as the sand in place; thus, laboratory determinations of its hydraulic properties probably approach the actual hydraulic properties of the sand in place. Therefore, it is possible to approximate the field coefficient commonly used for evaluation of an aquifer—the coefficient of transmissibility—by computations using the laboratory data.

As can be seen from the definitions above, the coefficient of transmissibility of an aquifer equals the field coefficient of permeability times the thickness of the aquifer, in feet. The average coefficient of permeability determined by laboratory analysis for 4 samples is 470 gpd per square foot at 60°F. The average thickness of the dune sand in the Florence area has not been determined; if it is 100 feet (probably a conservative estimate) and if the ground-water temperature is not far from 60°F, as is the case, then the coefficient of transmissibility is about 50,000 gpd per foot. This value for the coefficient of transmissibility compares closely with the results of extensive aquifer studies made independently at Coos Bay by the Pacific Power & Light Co., according to Mr. C. P. Davenport, Engineer (oral communication, January 1960).

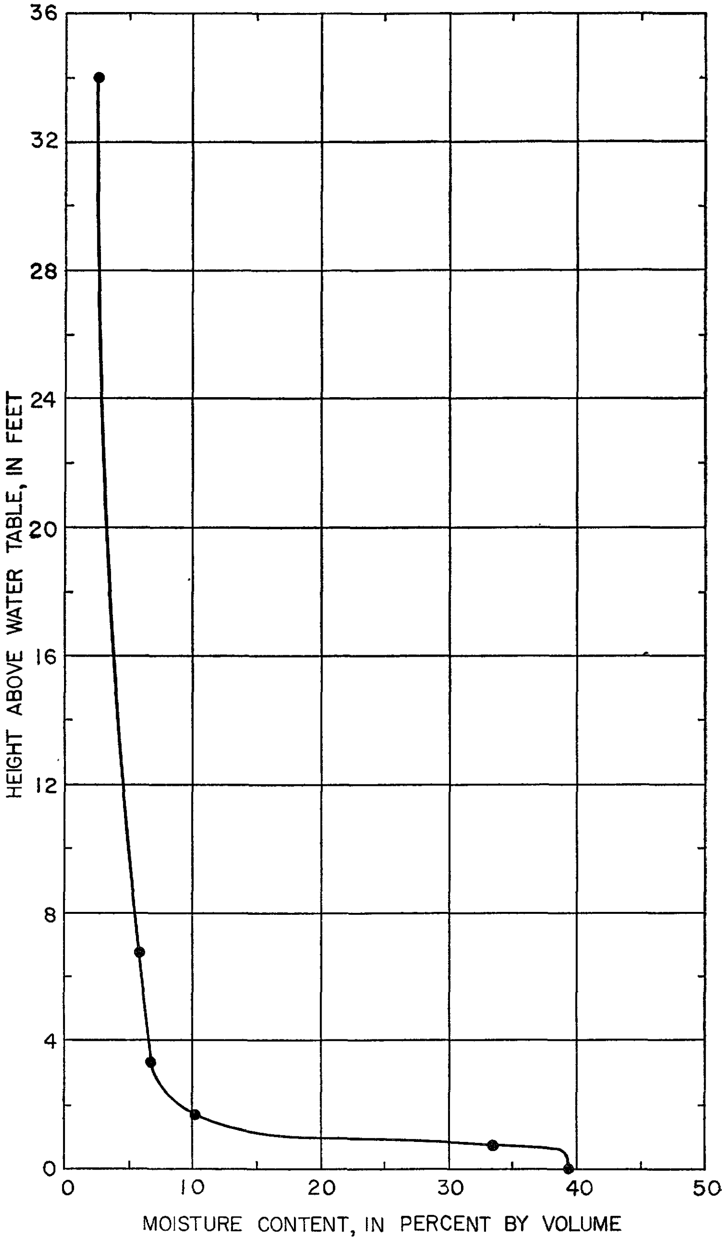



FIGURE 14.—Laboratory determination of distribution of moisture above the water table in a sand sample from well 18/12W–26B1.

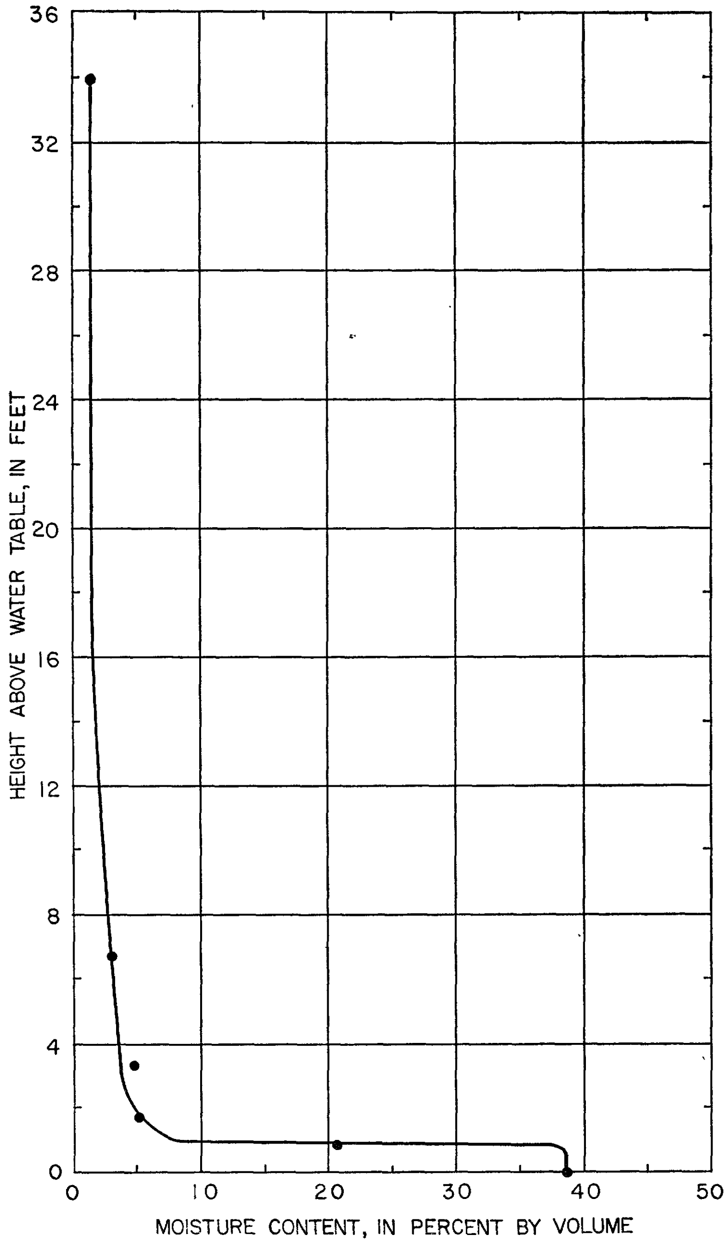



FIGURE 15.—Laboratory determination of distribution of moisture above the water table in a sand sample from well 18/12W–26B3.

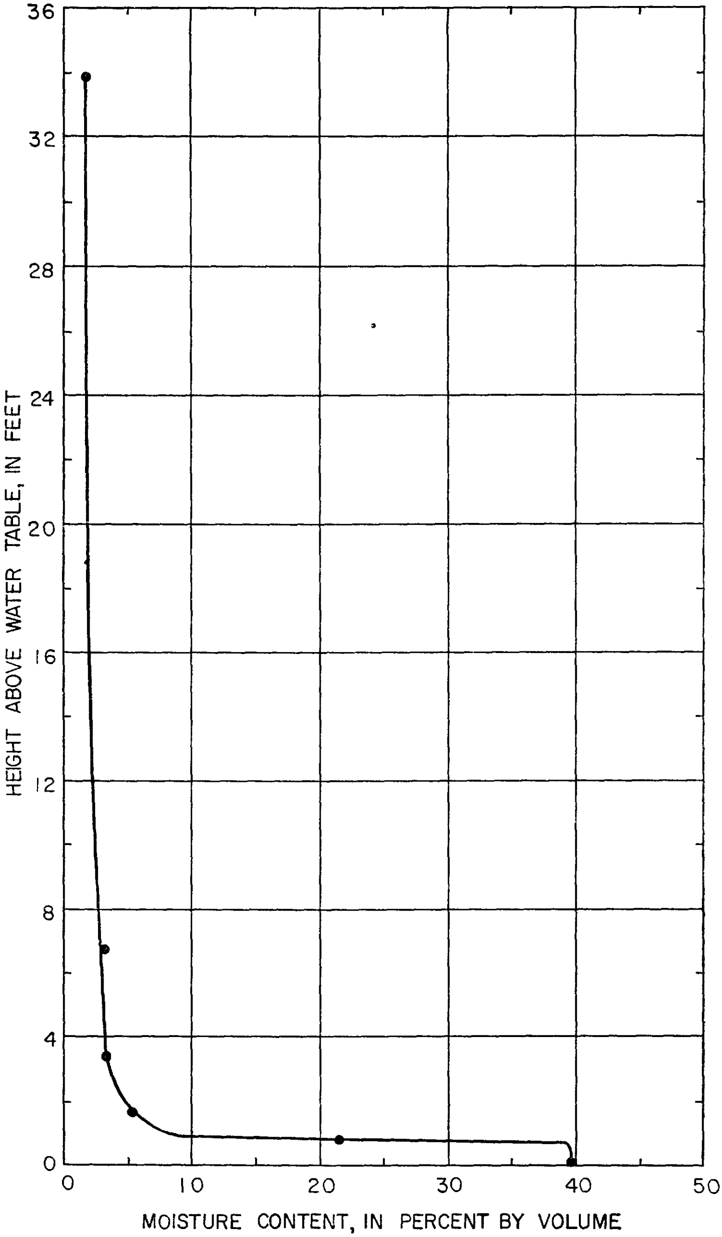



FIGURE 16.—Laboratory determination of distribution of moisture above the water table in a sand sample from well 18/12W–14R1.

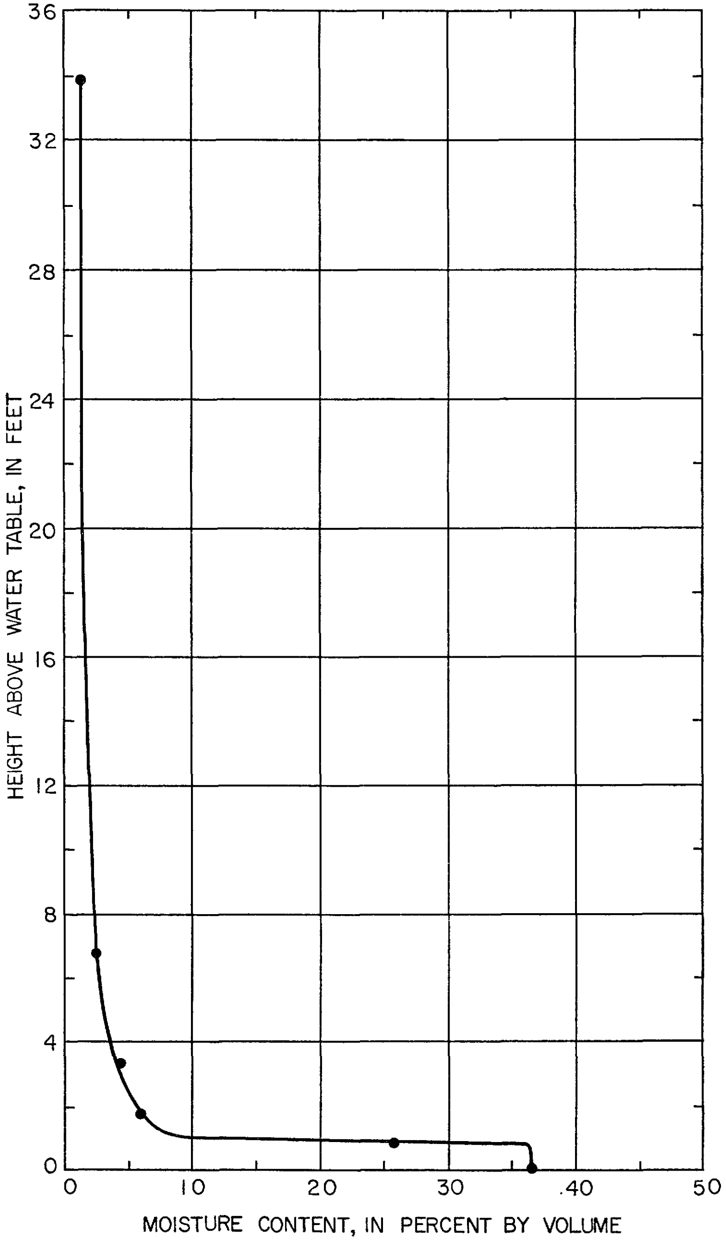



FIGURE 17.—Laboratory determination of distribution of moisture above the water table in sand sample from test hole 18/12W–23Q1.

In order to test the water-producing capabilities of shallow driven wells in the dune sand, 40-hour pumping tests were made on wells 18/12W–26B5 and 18/12W–14Q3. The pumped wells and all but two of the observation wells were 1¼ inches in diameter and were equipped with a 2.5-foot commercial well point having slotted openings 0.01 inch wide. Two of the observation wells were equipped with 5-foot well points. Wells 18/12W–26B5 and 14Q3 were driven to depths of 13.6 and 13.8 feet, respectively, below the land surface. These and the observation wells were developed by alternately pumping and hand surging until no appreciable increase in yield was noted. The yield of well 25B5 was 10 gpm when first pumped and 23 gpm after development; the average yield was 16.5 gpm during the 40-hour pumping test. The drawdown of water level in the well could not be measured during pumping, because the pump was connected directly to the top of the drive pipe; however, the drawdown could not have exceeded 6 feet, because only 6 feet of water stood over the top of the well screen at the beginning of the test. The drawdown in observation well 26B3, 5 feet from well 26B5, was 1.95 feet at the end of the test. The drawdown curves during the pumping test on well 14Q3 are shown on figure 18. The data from these tests are not adequate for determining the transmissibility of the dune sand as a whole, but they do show that shallow driven wells, properly constructed and adequately developed, are capable of producing water in amounts sufficient for domestic uses.

In an effort to determine the maximum yield from a properly constructed and screened well, test well 18/12W–14P4 was drilled; it is 6 inches in diameter and 59 feet deep (tables 5 and 6). The screen is 3½ inches in diameter and 15 feet long and has slot openings 0.01 inch wide. During development work, the well produced about 55 gpm with about 8 feet of drawdown. The well was not completely developed at the time of the short pumping test. A properly developed well of similar construction and screen length should be capable of producing at least 150 gpm.

## CHEMICAL QUALITY OF THE WATER

In order to determine the general chemical quality of the water within and effluent from the dune-sand aquifer, samples of water were collected and analyzed from 8 wells, 1 spring, and Munsel Creek. Of these, 4 samples were analyzed for all the major constituents usually included in a comprehensive water analysis, and 6 samples were analyzed only for chloride, iron content, and hardness.

Except for undesirable amounts of iron in samples from the spring and from well 18/12W–14N1, the waters sampled from wells in open

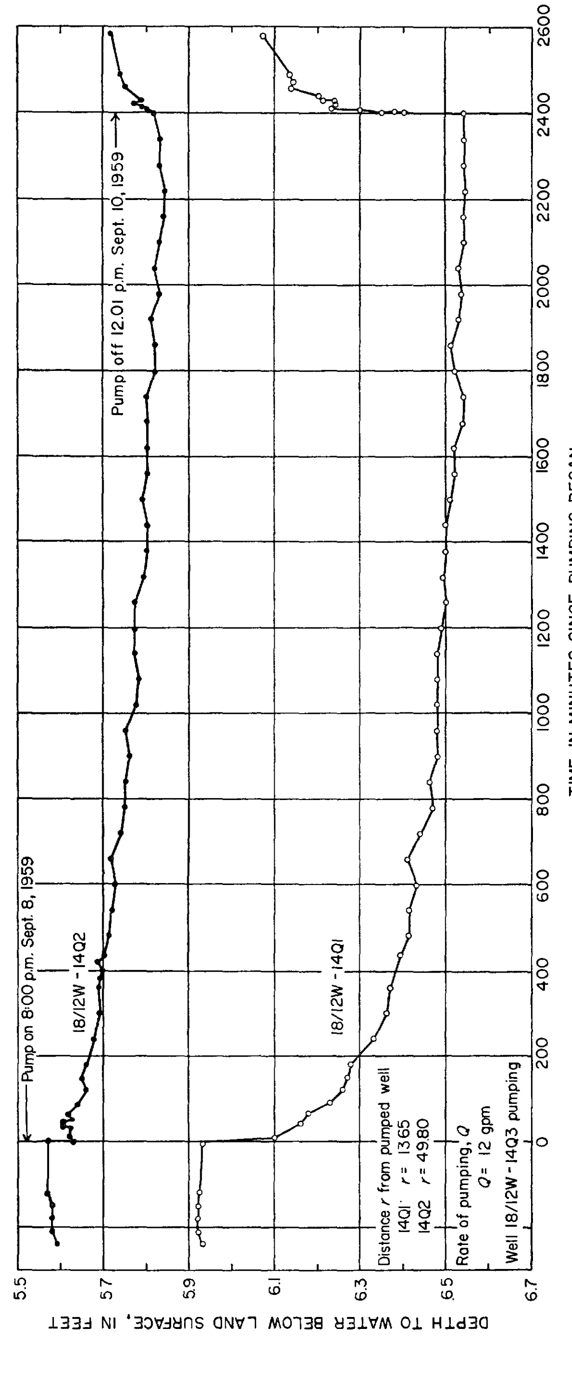



FIGURE 18.—Water levels in observation wells during a 40-hour pumping test in the dune area near Florence, Oreg.

sand areas, the spring, and the stream were of excellent quality for most domestic and industrial uses. Water from shallow wells in boggy or swampy areas (17/12W–35C1 and 18/12W–14R1) contained dissolved iron in amounts objectionable for most uses and also had objectionable odor, taste, and color. As is shown in table 4, all the water samples are weakly acidic. The pH values of the 4 samples so analyzed ranged from 5.6 to 6.2. A value of 7 indicates neutrality.

The highest iron content was 2.07 ppm (parts per million), in water from well 18/12W–14R1, which is in a swampy area; the lowest iron content, in water from well 18/12W–26B4, in the open sand, was 0.02 ppm. The average iron content of 9 samples, excluding that from well 18/12W–14R1, was 0.26 ppm. A combined content of iron and manganese in excess of 0.3 ppm is considered objectionable for domestic and public supply (U.S. Public Health Service, 1946, p. 384). Water containing amounts of iron exceeding this limit is likely to cause a reddish-brown staining of plumbing fixtures and of clothing washed in it.

## POTENTIAL GROUND-WATER SUPPLY FROM THE DUNE AREA

### ESTIMATED QUANTITY OF WATER AVAILABLE

As previously stated, of the annual average precipitation of 65 inches, an estimated 85 percent, or 55 inches, of water recharges the dune sand. Probably about 7 inches of the 55 is required to meet annual evapotranspiration losses; therefore, about 48 inches of water, over the entire dune area, is presently being discharged to the ocean. Most of this water is available for withdrawal. This means that as much as 2,600 acre-feet per year per square mile, or an average of 7 acre-feet per day (2.3 million gallons per day) per square mile of area possibly is available for withdrawal.

As the withdrawal of ground water from the dune sand increases in the future, the amount of water available for withdrawal might be increased substantially, either as a result of a general lowering of the water table or by means of artificial recharge.

At the height of the winter recharge period, the precipitation at places falls on saturated sands that reject any further recharge. If the storage capacity of the dune sand were increased by lowering the water table during the summer months by means of pumping from wells, much of the potential recharge that is rejected during the winter months could be taken into storage.

The dune sand is capable of accepting artificial recharge either by injection into wells or by spreading water over the surface of the dune area. If the future demand for water exceeds the supply from the natural recharge, it may become economically feasible to recharge the dune-sand aquifer artificially with water of good quality pumped from the nearby streams during high stages.

### POSSIBLE PROBLEMS OF CHEMICAL QUALITY

The presence of more than 0.3 ppm of iron in 4 of the 10 samples analyzed indicates that future wells in the area may obtain water having objectionable amounts of this constituent. The water may require treatment for iron removal before it would be suitable for uses requiring low iron content. The ground water in the area is weakly acidic and thus is corrosive to iron pipes. Corrective treatment, such as filtration through limestone, may be necessary to raise the pH and the alkalinity of the water and thus prevent corrosion to transmission pipes and other fixtures of a water system.

If the future ground-water withdrawal from the dune sand in the northern Florence area were increased beyond the annual recharge to the ground-water body, the water table would be lowered, and sea water would migrate inland and contaminate the supply. Sea-water intrusion probably would not occur under moderate and well-planned development. Nevertheless, large withdrawals or local overdraft could result in sea-water intrusion in the northern Florence dune area. Under present conditions this danger would exist only in wells located near the beach and drilled to depths at or near sea level.

Because the recharge to the dune sand a short distance from the beach is ample to maintain the water table at least several feet above sea level throughout the year, the natural hydrostatic pressure and seaward movement of the fresh water should be sufficient to hold back the sea water, even though withdrawals farther inland might lower the water table locally below sea level. Therefore, so long as the water table is maintained sufficiently high near the beach and near the Siuslaw River, on the southern and southwestern sides of the area, the sea water would be unable to migrate inland.

Any plans for near-maximum development of the ground-water resources in the area should include provisions for (a) test drilling to determine the total thickness of the dune sand and quality of water at several places along the periphery of the dune sheet, (b) maintaining a high water table along the seaward edge of the dune sheet, as described previously, and (c) constructing and maintaining a network of observation wells near the seaward edge of the dune sheet for periodic measurement of ground-water levels and chloride content of the ground water.

### POSSIBLE POLLUTION PROBLEMS

The presence of a number of septic tanks and other private sewage-disposal systems that discharge to the sand in the northern Florence dune area gives rise to the question of possible pollution of the aquifer by sewage effluent. This possible problem was not studied during this investigation but is believed not to be serious at the present time (1960). Because the sand is fine grained, it is an excellent filter. According to the conclusions of recent studies of the travel of pollution (California Water Pollution Control Board Staff, 1954, p. 164), the extent of travel of bacterial pollution in a similar fine-grained aquifer is so limited that recharge of the aquifer with sewage-plant effluents on the small present scale does not pose a serious problem, especially if wells are equipped with blank casing for at least 10 to 20 feet below the water table. However, chemical contaminants, such as those used in most detergents, could render the supply unfit for domestic use.

### WELL CONSTRUCTION IN DUNE SAND

The experience gained during this investigation, and in studies of the Coos Bay dune area made by the Geological Survey and independent studies made by the Pacific Power & Light Co., indicates that the most practical method of extracting water from the dune sand is by means of properly screened and developed wells. For optimum efficiency the wells would have to be screened through the full saturated thickness of the aquifer, allowing for drawdown during pumping, or through as great a thickness as is feasible either economically or in consideration of the possibility of pollution from nearby surficial sources. To prevent excessive drawdown and to avoid the possibility of sea-water intrusion in any one area, wells should be spaced for minimum mutual interference.

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Cooper, W. S., 1958, Coastal sand dunes of Oregon and Washington: Geol. Soc. America Mem. 72, p. 88–93, pl. 3.

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TABLE 4.—*Chemical analyses of water from wells and springs of the northern Florence dune area, Oregon.*

[Analyses by U.S. Geological Survey. Chemical constituents in parts per million]

| Well or spring number, or stream | 17/12W-35C1 | 18/12W-14E1 | 18/12W-14P3 | 18/12W-14Q1 | 18/12W-14R1 | 18/12W-22D1 | 18/12W-26B4 | 18/12W-26D1 | 18/12W-26F1 | Munsel Creek |
|---|---|---|---|---|---|---|---|---|---|---|
| Date of collection | 6-26-59 | 6-26-59 | 6-26-59 | 6-29-59 | 6-25-59 | 6-27-59 | 6-24-59 | 6-26-59 | 6-23-59 | 6-26-59 |
| | Well | Well | Well | Well | Well | Spring | Well | Well | Well | Stream |
| Temperature °F | | | | 53 | 55 | | 53 | | 54 | |
| Chemical constituents: | | | | | | | | | | |
| Silica ($SiO_2$) | | | | 6.5 | 9.8 | | 4.4 | | 6.2 | |
| Iron (Fe), total | 0.91 | 0.06 | 0.37 | .19 | 2.07 | 0.40 | .02 | 0.22 | .05 | 0.13 |
| Calcium (Ca) | | | | 1.0 | 1.5 | | 1.0 | | 1.0 | |
| Magnesium (Mg) | | | | .4 | 1.0 | | .1 | | .0 | |
| Sodium (Na) | | | | 3.8 | 5.8 | | 2.0 | | 4.3 | |
| Potassium (K) | | | | .6 | .4 | | .3 | | .5 | |
| Bicarbonate ($HCO_3$) | | | | 7 | 8 | | 4 | | 7 | |
| Carbonate ($CO_3$) | | | | 0 | 0 | | 0 | | 0 | |
| Sulfate ($SO_4$) | | | | 1.6 | .5 | | 1.4 | | .9 | |
| Chloride (Cl) | .95 | 2.8 | 13 | 4.2 | 10 | 13 | 3.5 | 7.5 | 2.8 | 11 |
| Fluoride (F) | | | | .0 | .0 | | .0 | | .0 | |
| Nitrate ($NO_3$) | | | | 1.3 | .7 | | .4 | | .2 | |
| Dissolved solids: | | | | | | | | | | |
| Calculated | | | | 23 | 34 | | 15 | | 19 | |
| Residue at 180°C | | | | 20 | 47 | | 14 | | 21 | |
| Hardness: | | | | | | | | | | |
| As $CaCO_3$ | 14 | 5 | 10 | 4 | 8 | 10 | 3 | 16 | 2 | 10 |
| Noncarbonate | | | | 0 | 1 | | 0 | | 0 | |
| Specific conductance (micromhos at 25°C) | 66 | 29 | 69 | 32 | 51 | 77 | 21 | 62 | 31 | 64 |
| pH | | | | 6.1 | 5.6 | | 6.2 | | 5.7 | |

TABLE 5.—*Records of representative wells in the northern Florence dune area, Oregon.*

Topography: All wells located in the northern Florence dune area; altitudes indicated in feet above sea level.
Type of well: Dr, drilled; Dv, driven.
Ground-water occurrence: C, confined (artesian); U, unconfined (watertable).
Use: D, domestic; O, observation; PS, public supply.
Water level: Depth given in feet and decimals measured by the Geological Survey; those in whole feet reported by owner or driller.
Datum for water levels and screen interval is land surface at well.

| Well | Owner or occupant | Approximate altitude | Type of well | Depth of well (feet) | Diameter of well (inches) | Depth of casing (feet) | Screened interval (feet) | Character of water-bearing material | Ground-water occurrence | Water level: Feet below datum | Water level: Date | Yield (gallons per minute) | Use | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *T. 17 S., R 12 W.* | | | | | | | | | | | | | |
| 35C1 | U.S. Forest Service | 37 | Dv | 12.8 | 1¼ | 10.8 | 10.8–12.8 | Dune sand | U | 4.70 | 6–25–59 | | O | See table 4. |
| 35C2 | do | 37 | Dr | 131 | 6 | 66 | | Sandstone | C | 1 | 5– –59 | 20 | PS | Supplies camp ground. See table 6. |
| 35E1 | Sutton-by-the-Sea | 30 | Dr | 41 | 6 | 36 | 36–41 | Dune sand | U | 3.17 | 9–18–59 | 35 | D | Supplies small housing development. See table 6. |
| | *T. 18 S., R. 12 W.* | | | | | | | | | | | | | |
| 2K1 | Mr. Willsie | 119 | Dv | 13.6 | 1¼ | 11.1 | 11.1–13.6 | do | U | 5.50 | 8–28–59 | 20 | O | |
| 9A1 | C. A., Bonnett | 80 | Dr | 78 | 6 | 73 | 73–78 | do | U | 40 | 1950 | | | See table 6. |
| 11K1 | U.S. Geological Survey. | 101 | Dv | 6.4 | 1¼ | 3.9 | 3.9–6.4 | do | U | 2.70 | 8–28–59 | 15 | O | |
| 11N1 | M. J. Blick | 101 | Dv | 17.5 | 1¼ | 15 | 15–17.5 | do | U | 11.72 | 8–27–59 | 5 | O | |
| 14B1 | Siuslaw Rod and Gun Club. | 96 | Dv | 14.1 | 1¼ | 11.6 | 11.6–14.1 | do | U | 6.15 | 6– 4–59 | 10 | O | |
| 14D1 | U.S. Geological Survey. | 88 | Dv | 13.3 | 1¼ | 10.8 | 10.8–13.3 | do | U | 4.36 | 8– 6–59 | 10 | O | |
| 14E1 | do | 88 | Dv | 10.3 | 1¼ | 7.7 | 7.7–10.3 | do | U | 4.4 | 6– 4–59 | 15 | O | See table 4. |
| 14P1 | do | 72 | Dv | 15.3 | 1¼ | 12.8 | 12.8–15.3 | do | U | 8.55 | 6– 2–59 | 10 | O | |
| 14P2 | do | 66 | Dv | 10.5 | 1¼ | 8.0 | 8.0–10.5 | do | U | 4.44 | 6– 4–59 | 10 | O | |
| 14P3 | do | 67 | Dv | 9.7 | 1¼ | 7.2 | 7.2–9.7 | do | U | 2.7 | 6– 4–59 | 10 | O | See table 4. |
| 14P4 | do | 70 | Dr | 59 | 6¼ | 44 | 44–59 | do | U | 9.5 | 12–18–59 | 50 | O | Well drilled to 81 feet, filled to 59 feet. See table 6. |
| 14Q1 | do | 67 | Dv | 12.9 | 1¼ | 10.4 | 10.4–12.9 | do | U | 5.28 | 6– 4–59 | 10 | O | See table 4. |
| 14Q3 | do | 67 | Dv | 13.8 | 1¼ | 11.3 | 11.3–13.8 | do | U | 5.68 | 9– 8–59 | 12.5 | O | |
| 14R1 | do | 51 | Dv | 9.4 | 1¼ | 6.9 | 6.9–9.4 | do | U | 2.95 | 6–25–59 | 10 | O | See table 4. |
| 15M1 | Cecil Ames | 40 | Dr | 87 | 6 | 82 | 82–87 | do | U | 35 | 8– –59 | 13 | D | See table 6. |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23D1 | U.S. Geological Survey. | 73 | Dv | 14 | 1¼ | 11.5 | 11.5–14 | do | U | 7.30 | 6- 4-59 | 10 | O | |
| 23K1 | do | 40 | Dv | 7.7 | 1¼ | 5.2 | 5.2–7.7 | do | U | 2.35 | 6- 4-59 | 5 | O | |
| 26B1 | do | 31 | Dv | 12.4 | 1¼ | 7.4 | 7.4–12.4 | do | U | 4.35 | 6-22-59 | 10 | O | |
| 26B2 | do | 37 | Dv | 13.9 | 1¼ | 11.4 | 11.4–13.9 | do | U | 8.56 | 6- 4-59 | 10 | O | |
| 26B3 | do | 31 | Dv | 11.6 | 1¼ | 6.6 | 6.6–11.6 | do | U | 4.16 | 6-24-59 | 10 | O | |
| 26B4 | do | 30 | Dv | 10.1 | 1¼ | 7.6 | 7.6–10.1 | do | U | 3.28 | 6-24-59 | 10 | O | See table 4. |
| 26B5 | do | 31 | Dv | 13.6 | 1¼ | 11.1 | 11.1–13.6 | do | U | 4.09 | 6- -59 | 23 | O | Used as pumped well in pumping test. |
| 26D1 | do | 43 | Dv | 15.4 | 1¼ | 12.9 | 12.9–15.4 | do | U | 9.20 | 12-10-59 | 15 | O | |
| 26F1 | do | 25.5 | Dv | 15.2 | 1¼ | 12.7 | 12.7–15.2 | do | U | 10.19 | 6-22-59 | 10 | O | See table 4. |
| 26L1 | City of Florence | 24.5 | Dv | 24.4 | 1¼ | 21.9 | 21.9–24.4 | do | U | 16.37 | 8- 6-59 | 5 | O | |

TABLE 6.—*Drillers' logs of representative wells*

| | Thickness (feet) | Depth (feet) |
|---|---|---|
| **17/12W-25E1. Sutton-by-the-Sea. Drilled by C. E. Panschow, 1959** | | |
| Deposits of Quaternary age: | | |
| Sand, dune | 18 | 18 |
| Silt, wood, and sand | 6 | 24 |
| Sand, dune | 18 | 42 |
| **17/12W-35C2. U.S. Forest Service. Drilled by C. E. Panschow, 1959** | | |
| Deposits of Quaternary age: | | |
| Sand, dune, yellow | 20 | 20 |
| Sand, blue; silt and peat | 20 | 40 |
| Log, fir(?) | 6 | 46 |
| Sand, blue; silt and peat | 14 | 60 |
| Tyee formation: | | |
| Clay, blue | 4 | 64 |
| Sandstone | 61 | 125 |
| Shale, gray-blue | 6 | 131 |
| **18/12W-9A1. C. A. Bonnett. Drilled by C. E. Panschow, 1950** | | |
| Deposits of Quaternary age: | | |
| Sand, dune | 40 | 40 |
| Hardpan (silt and sand?) | 4 | 44 |
| Sand, beach, water-bearing | 34 | 78 |
| **18/12W-14P3. U.S. Geological Survey. Drilled by C. E. Panschow, 1959** | | |
| Deposits of Quaternary age: | | |
| Sand, dune, fine-grained, gray | 27 | 27 |
| Peat, dark-brown, and wood | ½ | 27½ |
| Sand, dune, fine-grained, gray | 25 | 52½ |
| Peat, dark-brown, and wood | ½ | 53 |
| Sand, dune | 28 | 81 |
| **18/12W-15M1. Cecil Ames. Drilled by C. E. Panschow, 1959** | | |
| Deposits of Quaternary age: | | |
| Sand, "beach" | 35 | 35 |
| Silt and clay | 2 | 37 |
| Sand, streaks of wood, and silt | 30 | 67 |
| Clay, brown | 2 | 69 |
| Peat, and sand | 3 | 72 |
| Sand, gray, clean, with streaks of peat | 15 | 87 |
| **18/12W-26L1. City of Florence. Driven by U.S. Geological Survey, 1959** | | |
| Deposits of Quaternary age: | | |
| Sand, dune | 24 | 24 |